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ABSTRACT

Ways in which to accommodate learning disabled students in a college course on electricity are considered by a professor involved with the HELDS project (Higher Education for Learning Disabled Students). He suggests that knowledge of the student's presentation, imagination in devising new methods, and ability to improvise are important assets. Among methods cited are a detailed course outline, highlighting printed materials, use of audiovisual materials, repetition, and unorthodox lecture presentations. Appendices include a course outline and sample lessons. (CL)

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ED234563

TEACHING ELECTRICITY WITH LEARNING DISABLED STUDENTS

By
Gerald Brunner

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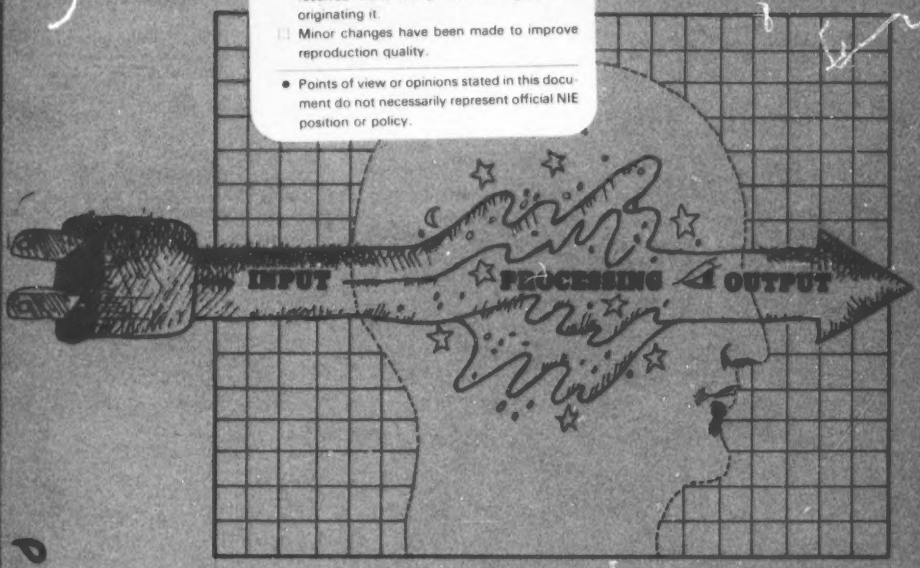

EC160430

THE HELDS PROJECT SERIES
CENTRAL WASHINGTON UNIVERSITY

2

TEACHING ELECTRICITY WITH LEARNING DISABLED STUDENTS

Alternative Techniques for Teaching Electricity to Learning Disabled Students in the University

by
Gerald F. Brunner
Assistant Professor of Technology and Industrial Education
Central Washington University

HELDS Project
(Higher Education for Learning Disabled Students)

Instructional Media Center
Central Washington University
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Participating Faculty

Marco Bicchieri, Anthropology
E. E. Bilyeu, Foreign Language
Ken Briggs, Health Education
Gerald Brunner, Technical and
Industrial Education
Owen Dugmore, Psychology and Counseling
Roger Garrett, Communication
Darwin Goodey, Psychology
Helmi Habib, Chemistry
John Herum, English
Zoltan Kramar, History
Cheryl McKernan, Academic Skills Center
Jan Reinhardtsen, Special Education
Roger Reynolds, Mass Media
Catherine Sands, Anthropology
Frank Sessions, Sociology
John Utzinger, Philosophy
O. W. Wensley, Speech and Audiology
Karl Zink, English

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THE HELDS PROJECT AT CENTRAL WASHINGTON UNIVERSITY

The acronym HELDS stands for Higher Education for Learning Disabled Students. It represents a model program funded for three years (1980-1983) by the Fund for the Improvement of Post Secondary Education (FIPSE), a division of the Department of Education. This project was funded as a model for other colleges and universities that are preparing to provide equal academic access for the learning disabled students.

Project HELDS had three major focuses. The first was to provide such access for the learning disabled student under Section 504 of the Rehabilitation Act of 1973. This we did for learning disabled students, most of whom were admitted without modified requirements to Central Washington University. These students were not provided remedial classes. They were enrolled in classes with other college students. The help that we gave was habilitative, rather than remedial, teaching them how to compensate for their weaknesses.

The habilitative training began with identification of those who were learning disabled and included, but was not limited to, such support services as taped textbooks (provided through the services of our Handicapped Student Services Coordinator), readers, writers for tests, extended time for tests, pre-registration with advising to ensure a balanced schedule, the teaching of study skills and tutoring by tutors from the campus-wide tutoring program who were especially trained to tutor learning disabled students.

The second focus of the project was to give a core of twenty faculty teaching classes in the basic and breadth areas a sensitivity to the characteristics of students who were learning disabled so that they could modify their teaching techniques to include the use of more than one modality. This ensured an academic environment conducive to learning for the LD. The faculty members participated in monthly sessions which featured experts in the field of learning disabilities, and in the area of the law (Section 504) that deals with the handicapped student and higher education. There were several sessions in which Central Washington University graduates and currently enrolled LD students shared their viewpoints and experiences with the faculty members. As a result of this some faculty members used the students as resource people in developing curricula for their various disciplines published in this series.

The third focus of the project was to make the university community aware of the characteristics of learning disabilities and of the program at Central. It also sought to encourage other colleges and universities to initiate such programs.

WHAT IS A LEARNING DISABLED STUDENT?

People with learning disabilities have handicaps that are invisible. Their disability is made up of multiple symptoms that have been with them since childhood. Many of them have been described as "dyslexics," but if they are categorized as dyslexic, this will be only one of their many symptoms, as a sore throat is only one of the many symptoms of a cold.

Three concise descriptions of the learning disabled children are provided in Hallahan and Kauffman:

"The National Advisory Committee on Handicapped Children (1968) proposed the following definition, which was adopted by the 91st Congress:

> Children with special disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written thinking, talking, reading, writing, spelling, or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or to environmental disadvantage.

Task Force II of a national project (Minimal Brain Dysfunction in Children: Educational, Medical and Health Related Services, Phase Two of a Three-Phase Project, 1969) wrote the following two definitions:

> Children with learning disabilities are those (1) who have educationally significant discrepancies among their sensory-motor, perceptual, cognitive, academic, or related developmental levels which interfere with the performance of educational tasks; (2) who may or may not show demonstrable deviation in central nervous system functioning; and (3) whose disabilities are not secondary to general mental retardation, sensory deprivation or serious emotional disturbance.
>
> Children with learning disabilities are those (1) who manifest an educationally significant discrepancy between estimated academic potential and actual level of academic potential and actual level of academic functioning as related to dysfunctioning in the learning process; (2) who may or may not show

demonstrable deviation in central nervous system functioning; and (3) whose disabilities are not secondary to general mental retardation, cultural, sensory and/or educational deprivation or environmentally produced serious emotional disturbance.[1]

Although the preceding definitions are concerned with children, the President's Committee on Employment of the Handicapped, in their booklet *Learning Disability: Not just a Problem Children Outgrow*, discusses LD adults who have the same symptoms they had as children. The Department of Education (Reference Hallahan & Kauffman) says that two to three percent of the total public school population are identified as learning disabled and that there are over fifteen million unidentified LD adults in the United States, acknowledging, of course, that people with this problem are not restricted to the United States but are found all over the world.

We know that many learning disabled persons have average or above average intelligence and we know that many of these are gifted. In their company are such famous gifted people as Nelson Rockefeller, Albert Einstein, Leonardo da Vinci, Thomas Edison, Hans Christian Anderson, Auguste Rodin, William Butler Yeats, and Gustave Flaubert.

The causes of learning disabilities are not known, but in our project each of our identified learning disabled students shows either an unusual pregnancy (trauma at birth, such as delayed delivery, prolonged or difficult delivery) or premature birth. They oftentimes have a genetic family history of similar learning disability problems.

An exerpt from my *Criterion and Behavioral Checklist for Adults With Specific Learning Disabilities* has been included as Appendix A.

/s/ MCS
6 June 1982
Ellensburg, Washington

[1]Daniel P. Hallahan and James M. Kauffman *Exceptional Children* (Englewood Cliffs, New Jersey: Prentice-Hall, 1978), pp. 121-122.

TEACHING ELECTRICITY WITH LEARNING DISABLED STUDENTS

For a real challenge solve a Rubic's Cube problem behind your back—or teach an electricity course with learning disabled (LD) students. Are these two tasks being equated? The answer is a resounding NO!

At the beginning of the HELDS program I was really conscience-stricken concerning the validity of the problem. I was in a turmoil. Were these students in fact disabled, or were they the K-12 lazy loafers who were looking for a free ride through a college? It took a number of excellent presenters to convince this skeptic. Once this hurdle was passed many additional parts fell into place.

Teaching LDs is not an impossible task. It is not even difficult. At times it can be puzzling—at other times momentarily embarrassing, but the end result will be success and satisfaction.

To be successful with LDs requires three basics on the instructor's part: (1) a knowledge of the student's presentation; (2) a bit of energy and imagination in devising methods; and (3) an ability to "think on your feet." All of these are basics to any *good* teacher, and the end result will be the goal of any *good* teacher: student learning. Not only will the LD benefit, but all students will benefit from the methods used.

What do I do in a class with LDs that I do not do in another class? Really, nothing. Occasionally, I may have to make a minor concession because of a particular student's disability, but usually my classes are taught pretty much the same way with or without LDs in them.

The first thing I try to do is learn something about my students. I do this by having them write a short (one—two page) paper telling where they are from, their educational experience (See Appendix B1) and what their goals are: Why are you attending Central Washington University (see Appendix B1-2-3). A great deal can be learned by analyzing this paper for everything from handwriting and spelling to reading between the lines for things left unsaid. With student goals and experience in mind I can use these as explicit examples and specific applications of otherwise possibly nebulous concepts. I try to find out what the students' weak points are and work to strengthen them. In the case of the LD this may not work. Then a means of working around the weak point (disability) must be found. Here is where the second basic comes in.

None of my classes are straight lecture or straight demonstration or lecture-demonstration. As a matter of fact, they are a conglomerate of many teaching methods or modalities—some are conventional, some slightly unconventional and some could be considered downright crazy. I have been known to chase electrons down the chalk tray with a shoestring whip when describing the effect of voltage! Embarrassing? Only if you let it be. Effective? Yes.

I start the term by giving the student a course outline showing the topic for every day during the term (see Appendix C). This outline shows what will be discussed on any particular day, page references in the text, plus page references in one or more other books held on reserve in the campus library. The outline also shows assignments by title and "due dates" for them. It shows the number and title of the laboratory experiments with selected readings particularly pertinent to the experiment. Also on the outline is the title of any special printed handout or special audio visual tool to be used that day (see Appendix D and Appendix E).

The handouts are many and varied. Some are copies of research reports done by previous students. Some are written by me and some are copies of magazine articles reprinted with permission. All these printed handouts are intended to expand on the topic for the day and augment the text and class presentation.

What I have called "special" audio visual tools are those commercially prepared which the University Audio Visual Library has or acquires for me. These include eight and sixteen millimeter films, thirty-five millimeter film strips, two-by-two slides. The last two may or may not have accompanying taped audio.

By their nature these A.V. materials are very concise. They are used as a take-off point and/or review of a topic. With the title shown in the course outline, the student can go to the A.V. Library and view the materials a second or third time should the classroom presentation leave some blanks. Depending on the particular piece of A.V. material and other circumstances in relation to the topic, the A.V. material may be used as an introduction, a main presentation or a review of the day's topic.

There are also many visuals that I use on a daily basis that are far too numerous to show in the course outline. These are overhead transparencies, posters, and 2 x 2 slides that are kept in my own files. Most of these have been locally produced from my own sketches or by my own photography. These, too, are made available to the students but on a much more limited basis. Since most of these visuals do not have an explanation, either printed or visual, accompanying them, they are not too useful to the student.

Some of the visuals have been duplicated as handout material, especially if there is explanatory material to accompany them. Student notes are mostly very sparse and cannot be depended on. If the instructor writes notes, the students frequently will copy them to augment the non-explanatory visual.

To this end I write a lot. The chalk board is filled, erased and refilled several times during a period. Notes, formulas, math procedures or any other verbal presentation can be written as a second source of information. A chalk board, even a 16 or 24 foot one, fills quickly and must be erased, removing material that may be needed later. The overhead projector I use has a large roll of clear plastic foil to write on with a wax pencil or felt pen made for the purpose. This is a more permanent copy and can be referred to much later.

Some notes are used over and over again. When this is noted a permanent transparency is made and is used until it needs to be replaced.

On either the chalk board or the overhead projector a minimal ability to sketch, draw or cartoon is very helpful. Simple or even crude hand-drawn images will be remembered far longer than a spoken word.

Picking out or emphasizing should frequently be done. Colored chalk, colored felt pens and/or colored overlays get away from the "black and white blahs." Even underscoring or shadowing in color can emphasize or differentiate to make memory more permanent. Making visuals on colored foil is a welcome break from standard black on white and improves retention.

In addition to the above material the use of actual devices, cutaways and models has proven very helpful in the teaching-learning process. A cutaway of an automobile generator and/or alternator is a far better teaching tool than a picture or an attempt to give a verbal description.

One thing I DO NOT do is read to my classes. Materials that might be read are printed and given to the students. My vocal presentations are from brief outlines. In this way I am not tied to a lectern or podium.

I frequently move around the room. The students don't need to see me to hear me. *However*, if I have found in my first day inquiries that there is a hearing handicapped student in class, my movements are restricted by having to face that student.

My lecture methods might be considered unique. As I've indicated, I move freely in the classroom, especially when answering a student's question. This puts me into a more one-on-one position, but I have to be careful not to exclude the rest of the class. They are probably happy that someone else asked the question they needed answered. If a question appears to be pertinent to only the one student, I have no hesitancy in asking that student to hold it till after class. I do the same if I feel I cannot answer a particular question as well or as fully as is needed at the time. In this way we can spend as much time on explanations as necessary.

There are still questions which come up that I don't have an answer for. These I make a written note about and report the results the next day or two. If I don't know the answer to a pertinent question, I have no qualms about saying, "I don't know."

My actions in the classroom are anything but staid or pompous. I have, in fact, chased electrons with a whip. I have waved my arms like a windmill. I have jumped up and down. I have been said to almost dance down the aisles. I have banged on desks, kicked chairs, thrown chalk or erasers (not at students). At times I shout till I hear repercussions from adjacent colleagues; while at other times the students must listen hard to hear what I say the first time. I then repeat—louder.

My lectures are a series of repeats. First I tell them what I'm going to tell them. Next I tell them. Third, I tell them what I've told them.

As new material comes up which incorporates earlier information, I repeat that information—very much encapsulated—showing an ap-

plication, perhaps, or refreshing the memory. Likewise, if new information is related to future information, I briefly give this relationship.

In the main, my language is anything but esoteric or polysyllabic. I have been known to use current "slanguage"or mispronounce words deliberately if that will make for better understanding or may recall wandering thoughts of students or emphasize a point.

I have quoted from the classics of literature, the Bible and even lyrics of song to make a point. Sometimes these "quotes" are deliberate adaptations to the point at hand. Even mistakes, deliberate or accidental, can be used to keep the students functioning on the task of the moment.

To clarify a point, I frequently say the same thing using totally different wording. Here is where an unwritten lecture and very brief notes force my hand—or rather my heat. I must be able to think on my feet well enough to restate. Rote memory is a very poor second to an understanding. If the same wording, examples or analogies were used, the student would end up memorizing and regurgitating without understanding.

All of these modalities are of little avail if an LD student has a disability which is not overcome or compensated by the modalities. Then the teacher must make some concessions. The big question to many newcomers is, "Where do concessions end and coddling begin?"

What concessions can be made? If a student has trouble reading and understanding, a reader may be provided; a test may be given orally; more time may be allowed to complete work that has a short (e.g., a one-period test) time period. Some LDs may wish to tape record lectures. They can then listen to them as often as necessary. Providing them this opportunity and a front row seat is a very simple concession.

By allowing student access to the teacher, *all* students will benefit. This does not mean extra night or weekend access. It does mean making some concession or adjustment in so called "office hours" when we are available to students. A reasonable open door policy will give us the needed contact with our students. We will get to know them better than we would be by simply teaching "to them." We will correct improper understandings as they develop and develop a rapport with our students that can lead to only one thing: a better educated student. Isn't that why we are teaching?

Author's address:

Gerald F. Brunner
Department of Technology and Industrial Education
Central Washington University
Ellensburg, WA 98926
Telephone: (509) 963-3543

APPENDICES

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APPENDIX A

Criterion and Behavioral Checklist for Adults with Specific Learning Disabilities

1. Short attention span.

2. Restlessness.

3. Distractability. (The student seems especially sensitive to sounds or visual stimuli and has difficulty ignoring them while studying.)

4. Poor motor coordination. (This may be seen as clumsiness.)

5. Impulsivity. (Responding without thinking.)

6. Perseveration. (The student tends to do or say things over and over. Mechanism that says "finished" does not work well.)

7. Handwriting is poor. (Letters will not be well formed, spacing between words and letters will be inconsistent, writing will have an extreme up or down slant on unlined page.)

8. Spelling is consistently inconsistent.

9. Inaccurate copying. (The student has difficulty copying things from the chalkboard and from textbooks; for instance, math problems may be off by one or two numbers that have been copied incorrectly or out of sequence.)

10. Can express self well orally but fails badly when doing so in writing. In a few cases the reverse is true.

11. Frequently misunderstands what someone is saying. (For instance, a student may say, "What?", and then may or may not answer appropriately before someone has a chance to repeat what was said previously.)

12. Marked discrepancy between what student is able to understand when listening or reading.

13. Has trouble with variant word meanings and figurative language.

14. Has problems structuring (organizing) time -- The person is frequently late to class and appointments; seems to have no "sense of how long a "few minutes" is opposed to an hour; has trouble pacing self during tests.

15. Has problems structuring (organizing) space -- The student may have difficulty concentrating on work when in a large, open area -- even when it's quiet; may over or under-reach when trying to put something on a shelf (depth perception).

16. Has difficulty spacing an assignment on a page, e.g., math problems are crowded together.

17. Thoughts -- ideas wander and/or are incomplete in spoken and written language. Student may also have difficulty sequencing ideas.

18. Sounds -- A student's hearing acuity may be excellent, but when his brain processes the sounds used in words, the sequence of sounds may be out of order: e.g., the student hears "aminal" instead of "animal" and may say and/or write the "aminal."

19. Visual selectivity -- May have 20/20 vision but when brain processes visual information, e.g., pictures, graphs, words, numbers, student may be unable to focus visual attention selectively; in other words, everything from a flyspeck to a key word in a title has equal claim on attention.

20. Word retrieval problems -- the student has difficulty recalling words that have been learned.

21. Misunderstands non-verbal information, such as facial expressions or gestures.

22. Very slow worker -- but may be extremely accurate.

23. Very fast worker -- but makes many errors and tends to leave out items.

24. Visual images -- Has 20/20 vision but may see things out of sequence, e.g., "frist" for "first," "961" for "691." Or, a student may see words or letters as if they are turned around or upside down: e.g., "cug" for "cup," or "dub" for "bud," or "9" for "L" for "7," etc.

25. Makes literal interpretations. You will have to have them give you feedback on verbal directions, etc.

26. Judges books by their thickness because of frustration when learning to read.

27. Has mixed dominance: e.g., student may be right handed and left eyed.

28. Moodiness -- Quick tempered, frustration.

29. Cannot look people in the eyes and feels uncomfortable when talking to others.

30. Has trouble answering yes or no to questions.

Students with specific learning disabilities which affect their performance in math generally fall into two groups:

1. Those students whose language processing (input and output) and/or reading abilities are impaired. These students will have great difficulty doing word problems; however, if the problems are read to them, they will be able to do them.

2. Those students whose abilities necessary to do quantitative thinking are impaired. These students often have one or more problems such as the following:

A. Difficulty in visual-spatial organization and in integrating nonverbal material. For example, a student with this kind of problem will have trouble estimating distances, distinguishing differences in amounts, sizes, shapes, and lengths. Student may also have trouble looking at groups of objects and telling what contains the greater amount. This student frequently has trouble organizing and sequencing material meaningfully on a page.

B. Difficulty in integrating kinesthetic processes. For example, a student will be inaccurate in copying problems from a textbook or chalkboard onto a piece of paper. The numbers may be out of sequence or the wrong numbers (e.g., copying "6" for "5"). Problems may be out of alignment on the paper. Graph paper is a must for them.

C. Difficulty in visually processing information. Numbers will be misperceived: "6" and "9," "3" and "8" and "9" are often confused. The student may also have trouble revisualizing, i.e., calling up the visual memory of what a number looks like or how a problem should be laid out on a page.

D. Poor sense of time and direction. Usually, students in the second group have the auditory and/or kinesethic as their strongest learning channels. They need to use manipulative materials accompanied by oral explanations from the instructor. They often need to have many experiences with concrete materials before they can move on successfully to the abstract and symbolic level of numbers.

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APPENDIX B - 1

Initial Writing Sample

Construction Management major

No ¶ Minor

Sophomore

Klickitat High School Graduated 1980

Klickitat Wa.

Ive had no experience in electricity except for everyday use of appliences.

Im taking this course because it is in my major and it will also help in day to day uses.

APPENDIX B - 2

Initial Writing Sample

The reason why I want to be a Electrical Engineer is because I like working in the field of electronics but I wanted somethy more. I wanted a job where I can use activity and be insterty at the same time.

For E. E. I must go over 4 yr to take it. I also love Math and Physics, it amazes me how much people can do. I want to be a part of it.

APPENDIX B - 3

Initial Writing Sample

Construction work has always been very interesting to me. But I wouldn't always want to be someone else's flunkey. I've decided to major in Construction management. It will enable me to be around construction but at a management level. There is a large area of advancement available in the construction industry. I would like to get in on the ground floor of a construction company and grow with in the industry with the company. And maybe eventually own my own company which makes four years of school very worthwhile.

APPENDIX C

T-IE 271
BASIC ELECTRICITY

Credit:	5 hours
Meetings:	3 hours, 1 lecture and 4 hours lab per week
Place:	Hogue 215
Instructor:	Gerald F. Brunner
Text:	*Basic Electricity* by Van Valkenburgh, Nooger & Nelville, Inc. Volume 1,2,3,4, and 5
	Lab Manual — *Basic Electricity* by Abar and Schildkraut
	Wiring Simplified by Richter

GRADING

Experiments	35%
Problems	20%
Tests	35%
Notebook	10%

Your final grade will be based on the percentage of total possible points you earn. During the quarter you can approximate your letter grade according to the following scale which will be used at the end of the quarter to determine you final grade.

100 — 97%	A
96 — 93%	A-
92 — 90%	B+
89 — 87%	B
86 — 83%	B-
82 — 80%	C+
79 — 77%	C
76 — 73%	C-
72 — 70%	D+
69 — 67%	D

Anything below 67% is considered as failure.

GENERAL

1. Attend class regularly. If attendance is not necessary to complete the course, of what value is the instructor? Regular class attendance *is* necessary to complete the experiment, to participate in class discussions, and to obtain assignments.
2. There will be electrical experiments performed by the students.
3. There will be announced "check tests" as well as a test at the end of each text.
4. Assignments are due on the date stated by the instructor. Students will be expected to turn in assignments promptly. Full credit will not be given on work turned in late. You lose 10% per day late.
5. Reading assignments will be given frequently. You are responsible for these but are not limited to them.
6. All written work should be proofread, neat and orderly. Misspelled words, poor grammar and poor sentence structure are costly.

T-IE 271
BASIC ELECTRICITY

			Notes
Day 1	*Topic:*	Intro. to Course	
	Assign Study:	Vol. 1, p. 1-22	
	To Do:	Define electricity and electronics Due Monday	
Day 2	*Topic:*	Electricity, What it is — where it comes from	
	Assign Study:	Vol. I, p. 23-59 Read Lab Exp. 1,2,3	
Day 3	*Topic:*	Cells & batteries	
	Assign Study:	Vol I, p. 60-82 Vol II, p. 22-30	
	Read:	Handouts, prepare for Exp. 7	

Day 4	*Topic:*	Voltage — what it is & how to measure
	Do:	Lab 7
	Read:	Handouts
Day 5	*Topic:*	Cells & Batteries Care and feeding
	Assign:	Vol V, p. 1-44
	Prepare:	Lab Exp. 8
Day 6	*Topic:*	Resistance
	Do:	Exp. 10

Notes

Day 7	*Topic:*	Resistance
	Assign:	Vol I, p. 83 to end Read Handouts
	Do:	Math check test
Day 8	*Topic:*	Current, voltage, resistance interaction
	Assign:	Worksheet (practice)
	Prepare:	Exp. 11
Day 9	*Topic:*	OHM' s Law
	Do:	Exp. 11
Day 10	*Topic:*	Magnetism, transformers, generators
	Assign:	Review
	Prepare:	Exp. 12
Day 11	*Do:*	Exp. 12
Day 12		TEST I
Day 13	*Topic:*	OHM's Law, series circuits
	Assign:	Vol. II, p. 1-41
	Do:	Worksheet for grades, due Fri.
	Prepare:	Exp. 16

Day 14	*Topic:*	OHM's Law, parallel circuits
	Do:	Lab Exp. 16
	Assign:	Worksheet (practice)
Day 15	*Topic:*	OHM's Law, parallel circuits computing parallel resistance
	Prepare:	Lab Exp. 15, due Mon.
	Assign:	Worksheet (grade)
Day 16	*Topic:*	OHM's Law, parallel circuits
	Do:	Lab Exp. 15
	Assign:	Vol II, pp. 42-89
Day 17	*Topic:*	OHM'S Law, series-parallel circuits
	Assign:	Worksheet (practice)
Day 18	*Topic:*	Circuit analysis
	Prepare:	Exp. 18
	Assign	Vol II, pp. 90-116, due Fri. Worksheet (grade)
Day 19	*Topic:*	Series-parallel circuit
	Do:	Lab exp. 18
Day 20	*Topic:*	Review
	Prepare:	Lab 23
Day 21	*Topic:*	Circuit analysis
	Do:	Lab exp. 23
Day 22		TEST II
Day 23	*Topic:*	Power generation
	Assign:	Read handouts Lab exp. 4
Day 24	*Topic:*	Soldering
	Do:	Soldering

Day 25	*Topic:*	Power Distribution
	Prepare:	Exp. 42
	Assign:	Read exp. 39 and 41
Day 26	*Topic:*	Operation of oscilloscope
	Do:	Lab 42
Day 27	*Topic:*	Residential wiring
	Read:	Richter, "Wiring Simplified"
Day 28	*Topic:*	Residential wiring — components
	Prepare:	Wiring diagram, due Mon.
	Assign:	Electrical floor plan
Day 29	*Topic:*	Residential wiring
	Do:	House wiring
	Assign:	Vol III, pp. 1-42
Day 30	*Topic:*	Residential wiring — review
Day 31	*Topic*	Residential wiring
	Do:	House Wiring
Day 32	*Topic:*	TEST III
Day 33	*Topic:*	Inductive reactance
	Read:	Handouts
	Study:	Vol III, pp. 43-71
	Prepare:	Exp. 43
Day 34	*Topic:*	Frequency measurment with scope
	Do:	Exp. 43
	Assign:	Worksheet (practice)
Day 35	*Topic:*	Inductive reactance
Day 36	*Topic:*	Inductive reactance
	Do:	Exp. 44 (½)

Day 37	*Topic:*	Capacitive reactance
Day 38	*Topic:*	Capacitive reactance
	Assign:	Vol IV, pp. 1-25 Worksheet (practice)
Day 39	*Topic:*	Inductive reactance
	Do:	Exp 44 (½)
Day 40	*Topic:*	RC circuits
	Assign:	Vol IV, pp. 26-70 Worksheet (grade) due Mon.
	Prepare:	Lab exp. 49
Day 41	*Topic:*	Time Constant
	Do:	Lab exp. 49
Day 42	*Topic:*	LCR Circuits
Day 43	*Topic:*	LCR Circuits
	Assign:	Handouts
	Prepare:	Lab exp. 50
Day 44	*Topic*	Capacitive reactance
	Do:	Lab exp. 50
Day 45	*Topic:*	Impedance
	Assign:	Worksheet (practice)
Day 46		LAB FINAL
Day 47	*Topic:*	Resonance
	Assign:	Worksheet (grade) due Mon.
Day 48		LAB FINAL
Day 49	*Topic:*	Review
Day 50		LAB CLEAN UP

APPENDIX D

EUTECTIC STATE OF TIN — LEAD SOLDER EXPLAINED

The melting points of pure tin and pure lead, the two constituents of soft solders, are 232°C. and 327°C. respectively, but when they are mixed in the proportions of 63 percent of pure tin and 37 percent of pure lead, the melting point of this "eutectic" state is only 183°C. This melting, and solidfy.ng temperature is characteristic of this particular composition of pure tin and lead only. When molten mixtures of the two metals in other proportions undergo cooling, whatever amount of tin or lead they may contain in excess of the eutectic proportions of 63 or 37 respectively, crystallizes out gradually so causing the composition of the remaining liquid to crystallize eventually at 63/37 at the temperature of 183° C. At this temperature the solidifying solder will consist of a sludge of tin crystals or led crystals, whichever predominated originally, in fully liquid eutectic the fluid consistency of the sludge depends upon the relative proportions of crystals to eutectic. By selection of suitable amounts of tin and lead it is possible to devise solders which will have a thick consistency, rather like cement, which is useful for certain operations, such as the wiping of a joint on a pipe, because the semi-molten mass can be manipulated to any desired shape.

In other practical operations, however, it is necessary to avoid any slow setting stage, as for example when trying to obtain the highest possible speed in the soldering of printed circuits; for these cases the eutectic composition 63/37 is the best and it happens also to be the strongest.

Because of the practical importance of the tin-lead eutectic, many investigators have examined its structure and other physical characteristics. In the solid condition, the eutectic consists of parallel laminae of tin and lead alternately. The lead laminae are not pure, however, but are saturated with tin, just as the tin laminae are not saturated with lead. Why the laminal structure should come into being has not been fully established, but since the heats of crystallization of the two materials tin and lead differ considerably, some complicated energy relationships must be involved between the individual laminae. The latent heat of tin is 14.5 calories per gram and for the lead the figure is 6.26 calories per gram. On the assumption that the eutectic is a simple mixture, the linear average of the latent heats of the separate metals would give the figure 11.45 calories per gram of eutectic.

On the first principles it would seem likely that such a particularly orientated structure would involve some departure from the simple median relationship of the latent heats of the pure metals. Recently Moore and Elliot of the University of Manchester discussed undercooling at the solid/liquid interface of the lead-tin eutectic. Their work had the object of establishing the interphase-boundary energy in the system. The paper

describes the thermal valve furnace in which they investigated undercooling in a section between two thermo-couples placed one centimeter apart.

APPENDIX E

MEASURING CURRENT AND VOLTAGE

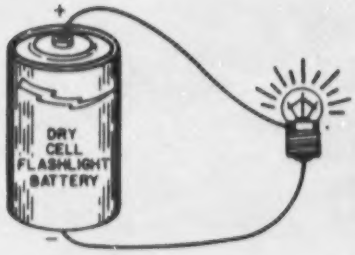


FIGURE 1

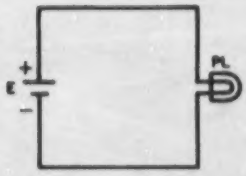


FIGURE 2

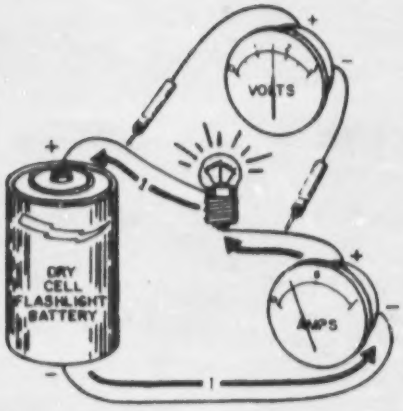


FIGURE 3

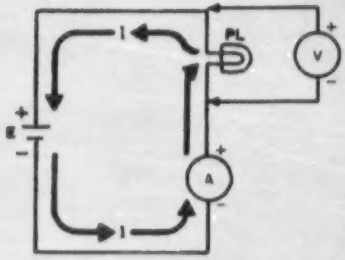


FIGURE 4

APPENDIX F

THE INDUCTION COIL

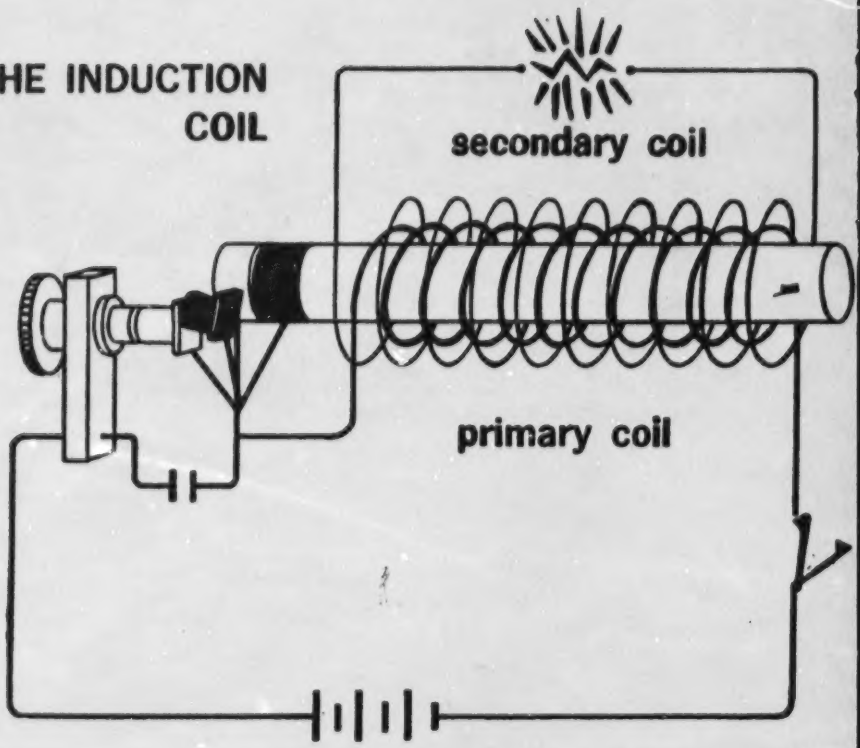


Fig. 1. Tin-lead fusion diagram shows eutectic point with alloy of 63% tin, 37% lead.

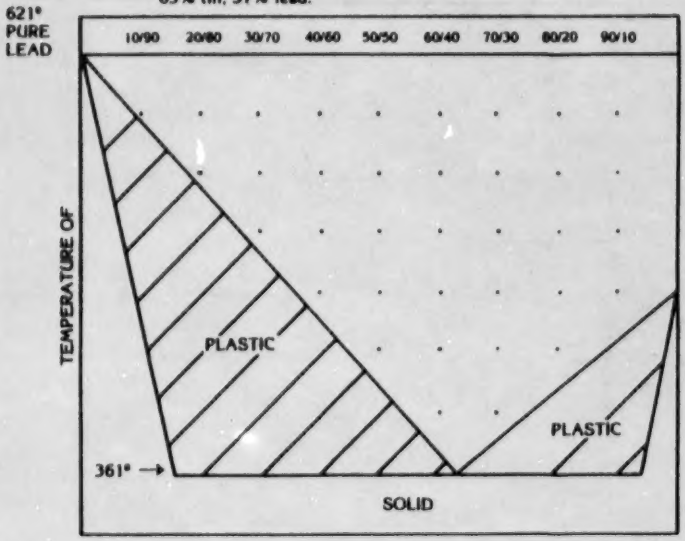
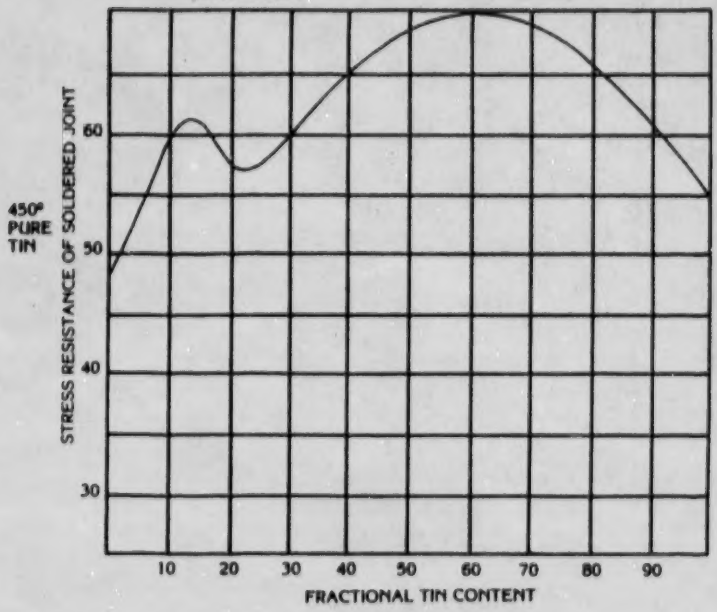


Fig. 2. Graph shows change in joining quality of tin-lead solders with increase in tin content, based on resistance of soldered joint to stress.



HELDS Project
Myrtle Snyder, Director HELDS
Educational Opportunities Program
Central Washington University
Ellensburg, Washington 98926
(509) 963-2131
EEO/AA/TITLE IX INSTITUTION